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**FINAL REPORT: Making Gliders Useful to Navy Operations**

**ONR N00014-05-1-0364**

**01-Mar-05 to 30-Sep-08**

Russ Davis and Dan Rudnick

The objectives of this project were (1) to improve the autonomous underwater glider Spray so it could be more easily used in Navy operations, (2) use Spray to carry out sampling that demonstrated glider capabilities within the framework of a one-month Navy operation in the Kuroshio; and (3) to construct 9 improved Spray gliders to build a glider facility headquartered at the Scripps Institution of Oceanography.

At the start of the grant (March 2005) Spray had been used only in scientific setting by its designers at Scripps and WHOI. The Naval Oceanographic Office (NAVO) was interested in evaluating gliders for ocean surveying. Davis participated in three planning meetings at Stennis and North Island. In June of 2005 a Spray was launched from a Naval Oceanographic Office (NAVO) ship in the Kuroshio region, flown without difficulty for one month, and recovered by the same NAVO ship at the end of the Navy field operation. During the operation, Spray profiles of temperature and salinity were relayed in real time to NAVO at Stennis where they were ingested into the Navy data assimilation system and used for forecasts.

During the four years of funding, we have undertaken a program to steadily improve Spray, to develop procedures to maintain and operate the glider, and to establish procedures for quality controlling and using the data it produces. A laboratory manual and set of checklists was written and then improved as new technicians were trained from it. Various small structural improvements were introduced including: dual antennas for both GPS and Iridium; a more reliable motor for the high-pressure pump; improved Argo back-up beacon; more reliable compass and altimeter; and improved battery supports. The program in the Spray controller was continuously updated improving the complex program determining glider behavior when sensor or systems failed as well as introducing new steering protocols including steering relative to the measured current and tracking smoothly toward a pre-determined track. Automatic quality control algorithms were added to the program that converts raw reports to scientific data. As a

result of all these improvements, the reliability of Spray gradually improved until we completed 2008 without a loss and only one cruise modified for mechanical reasons after completing 28 missions spanning 2560 days of operation.

To test research capabilities, we constructed a fleet of nine Sprays to be made available for ONR-sponsored oceanographic research studies. Spray gliders were provided for use in the Non-Linear Internal Waves Initiative. These gliders are deployed offshore of the Philippines south of the Luzon Strait, and are recovered off the east coast of Taiwan. Seagliders, provided by University of Washington in a collaborative effort, were deployed on the same schedule to double the size of the fleet sampling the Kuroshio.

Thirteen gliders (7 Sprays from SIO and 6 Seagliders from UW) were deployed and recovered in the Kuroshio in the region of the Luzon Strait starting in April 2007 and ending in June 2008. Turnarounds were done in July 2007, October 2007, and March 2008. Over 5000 dives to as deep as 1000 m were done as the gliders covered over 20,000 km in more than 1000 glider-days. A new recovery vehicle was used successfully on two occasions during the July 2007 recovery from the R/V Melville.

The technical objective of demonstrating the utility of a glider fleet in a region of strong currents has been achieved. Depth-average currents greater than 0.25 m/s (glider speed through the water) occurred 5-30% of the time depending on the deployment. In the presence of these strong flows, we were able to hit desired waypoints. Furthermore, we were able to cross the Kuroshio through the Luzon Strait on three separate occasions.

Two of these gliders were recently deployed off of Palau as a pilot for the Origins of the Kuroshio and Mindanao Current (OKMC) DRI. These gliders are currently in the North Equatorial Current making new observations of the waters that feed the Kuroshio and Mindanao Currents. These observations will help to guide more intensive field operations to follow.